2.4m Space Telescopes

Hardware Summary

November 20, 2012

ITT EXELIS

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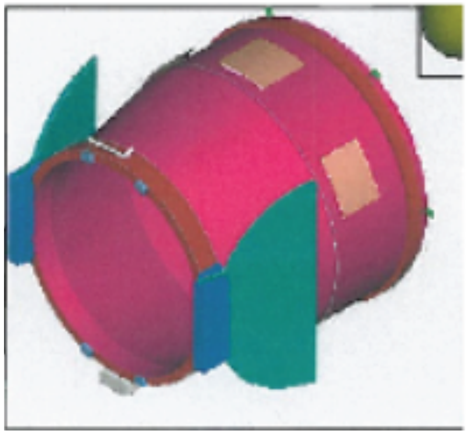
Hardware Summary

- Available Flight Hardware
  - Two, 2.4m, two-mirror telescopes
    - One completed with full thermal hardware
    - Electronics & Actuators have been harvested but can be rebuilt to existing drawings
  - Two outer barrel assemblies
    - One fully completed with thermal blankets and butterfly doors
  - One hardware radiator/electronics bays
    - Aluminum structures for radiator and electronic attachment
    - Acted as a "spacer" between the spacecraft and the outer barrel assembly
- All ground support equipment for alignment, integration, and test

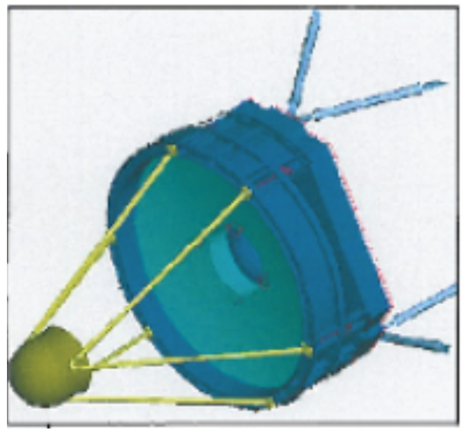
Robust traceability has been retained for all flight hardware

Hardware



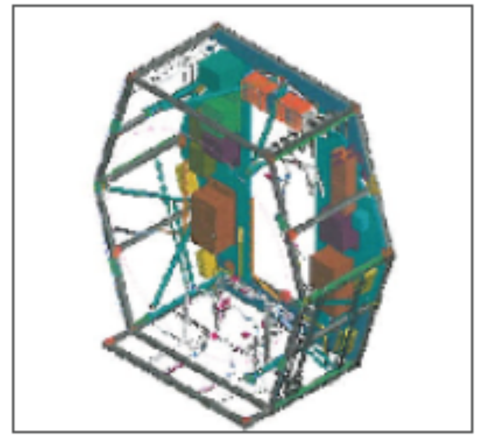
Outer Barrel Assembly (OBA)

2 Assemblies Available



Telescope Subsystem (TSS)

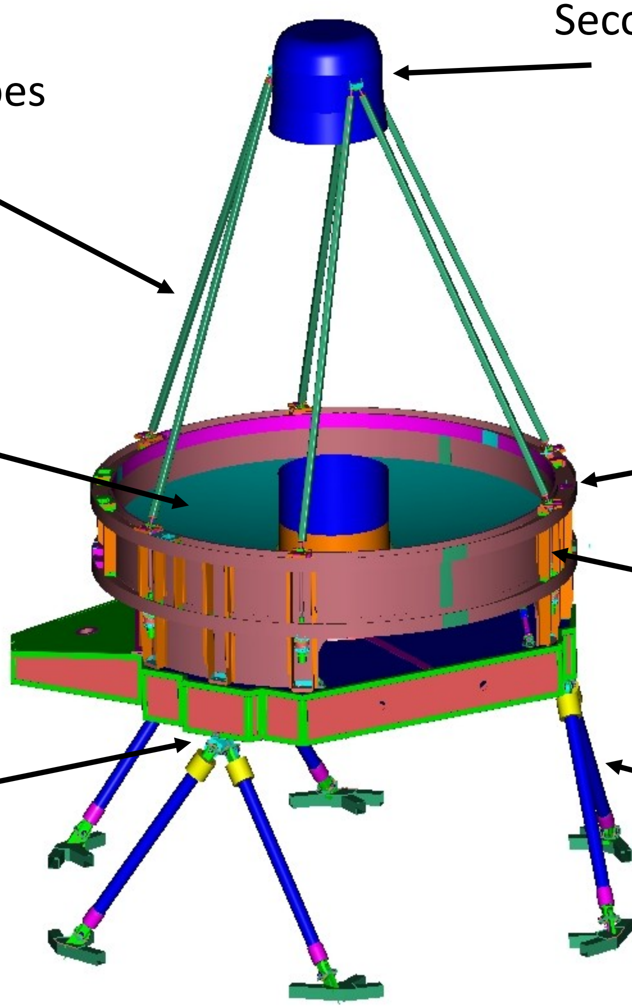
2 Assemblies Available



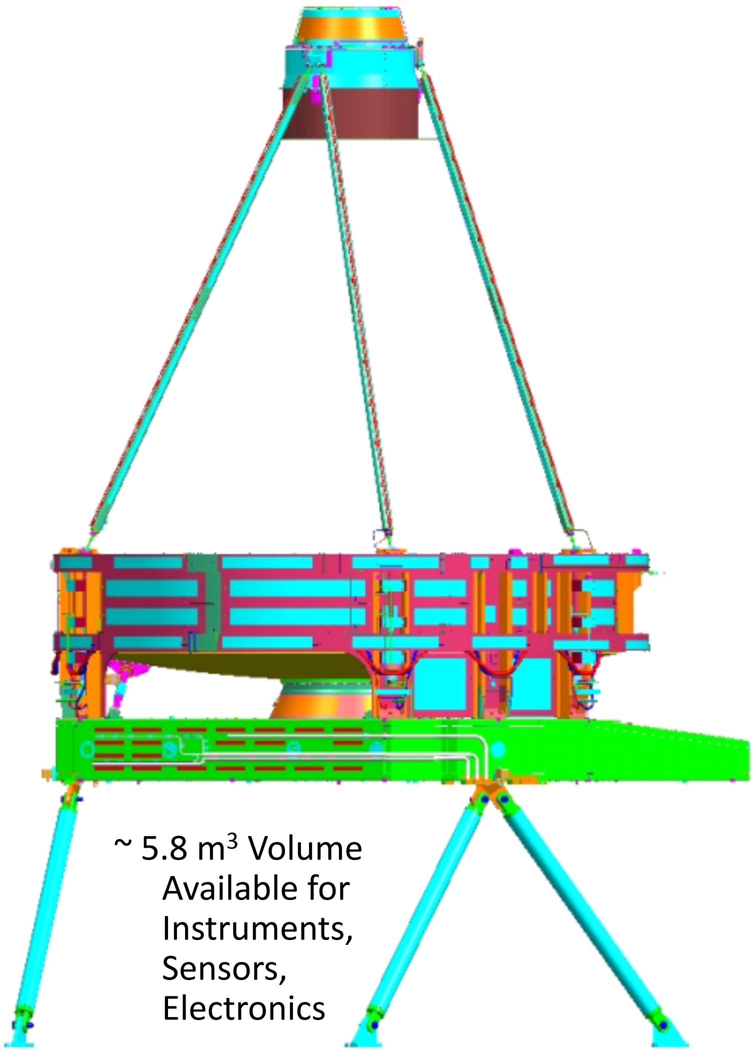
Payload Radiator Subsystem (PLRSS)

1 Assembly Available

Forward Optics Assembly (FOA) Configuration



2.4m Space Telescope Form

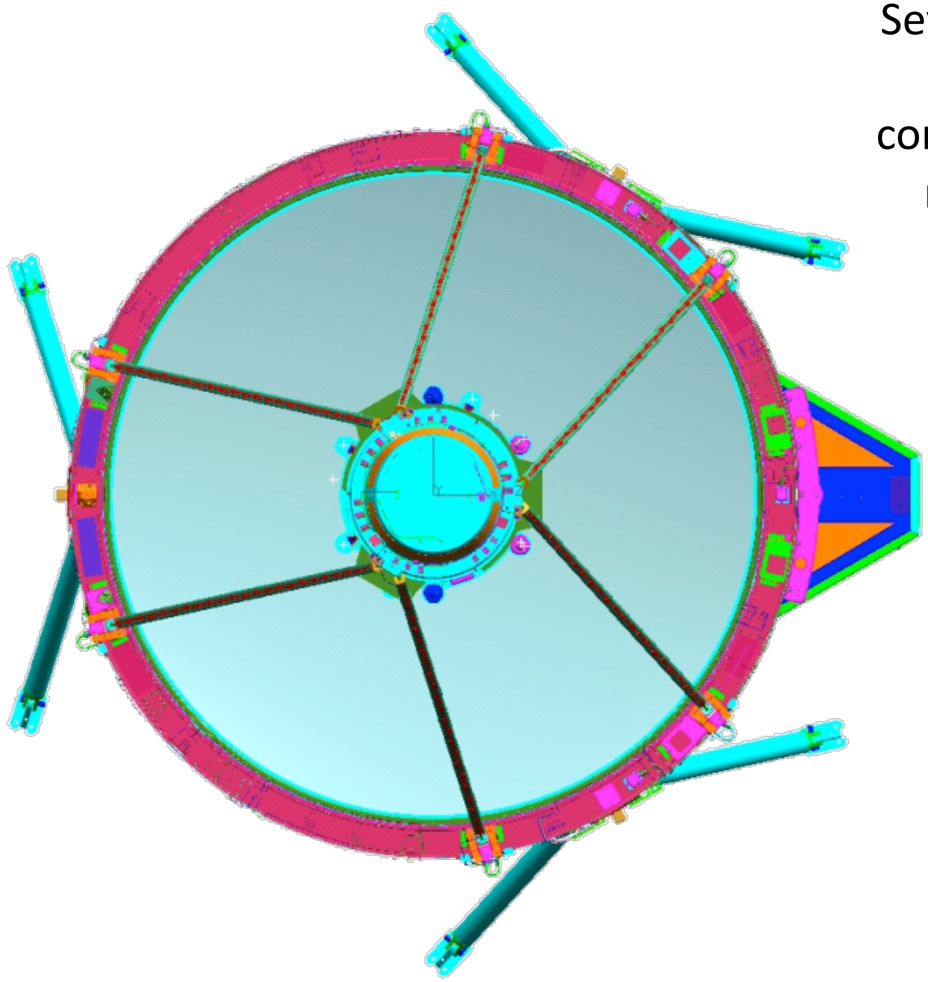


- **Optical Form: 2 Mirror, f/8**
- **Aperture: 2.37m**
- **Unvignetted Field of View: ~ 1.8^0 Dia.**
- **Wavefront Quality: <60 nm rms**
- **Secondary Mirror Assembly Control –**
  - **6 DOF plus fine focus**
    - ***6 DOF Actuators are at the base of the secondary struts***
    - ***Focus actuator is behind the SMA***
- **Mass: 840kg**
- **Back Focus: 1.2m behind PM Vertex**

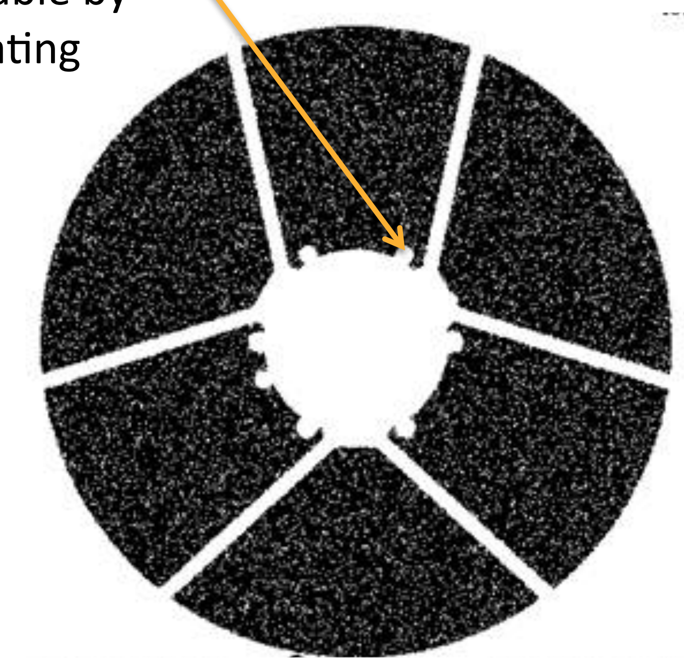
Outer Barrel Assembly

- **Thermal Protective Enclosure** ***including Two Actuated Thermal Butterfly Doors***
- **Composite Structure**
- **Full MLI blanket set also completed**
- **Mass: 280kg (without blankets)**
- **Mounting: Requires Interim Structure connected to Spacecraft Interface**

System Obstruction



Seven coating artifacts correctable by recoating



<u>On Axis Pupil</u>

17% Obstructed

Strut Mean Width: 41mm

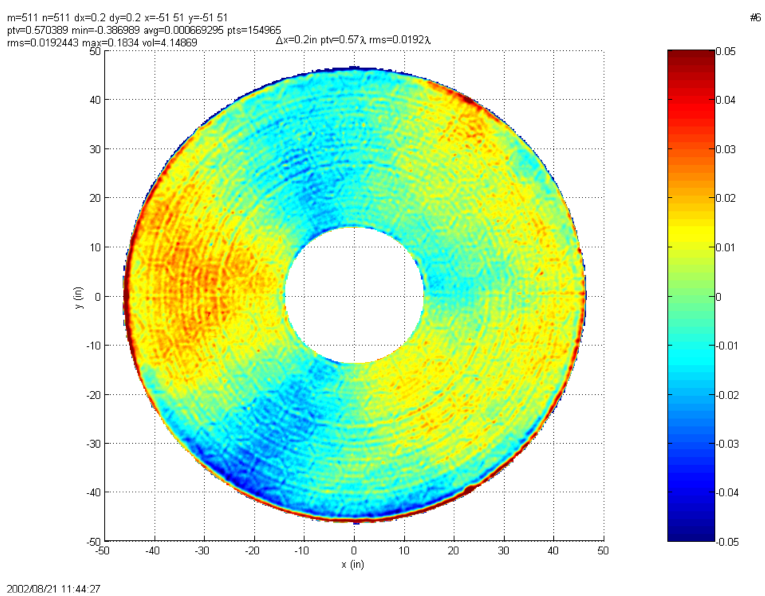
Strut Obstruction Length: 881mm

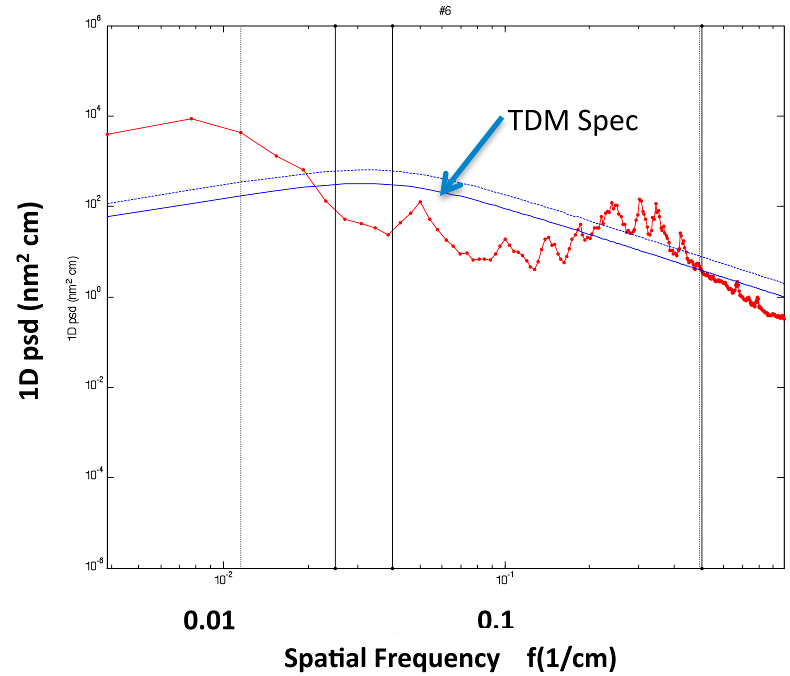
Mirror Quality and Coating

Primary Mirror (~40kg/m²)

Clear Aperture: 2.37m OD, 0.7m ID
Surface Quality: 12nm rms*

Form: Concave, F/1.2
Mirror Coating: Protected Silver





2 Dimensional Average PSD

Secondary Mirror

Clear Aperture: 0.53m OD, 0.02m ID
Surface Quality: 16nm rms

Form: Convex
Mirror Coating: Protected Silver

* To be verified with updated modeling techniques

PM Surface Figure Error at 250 K

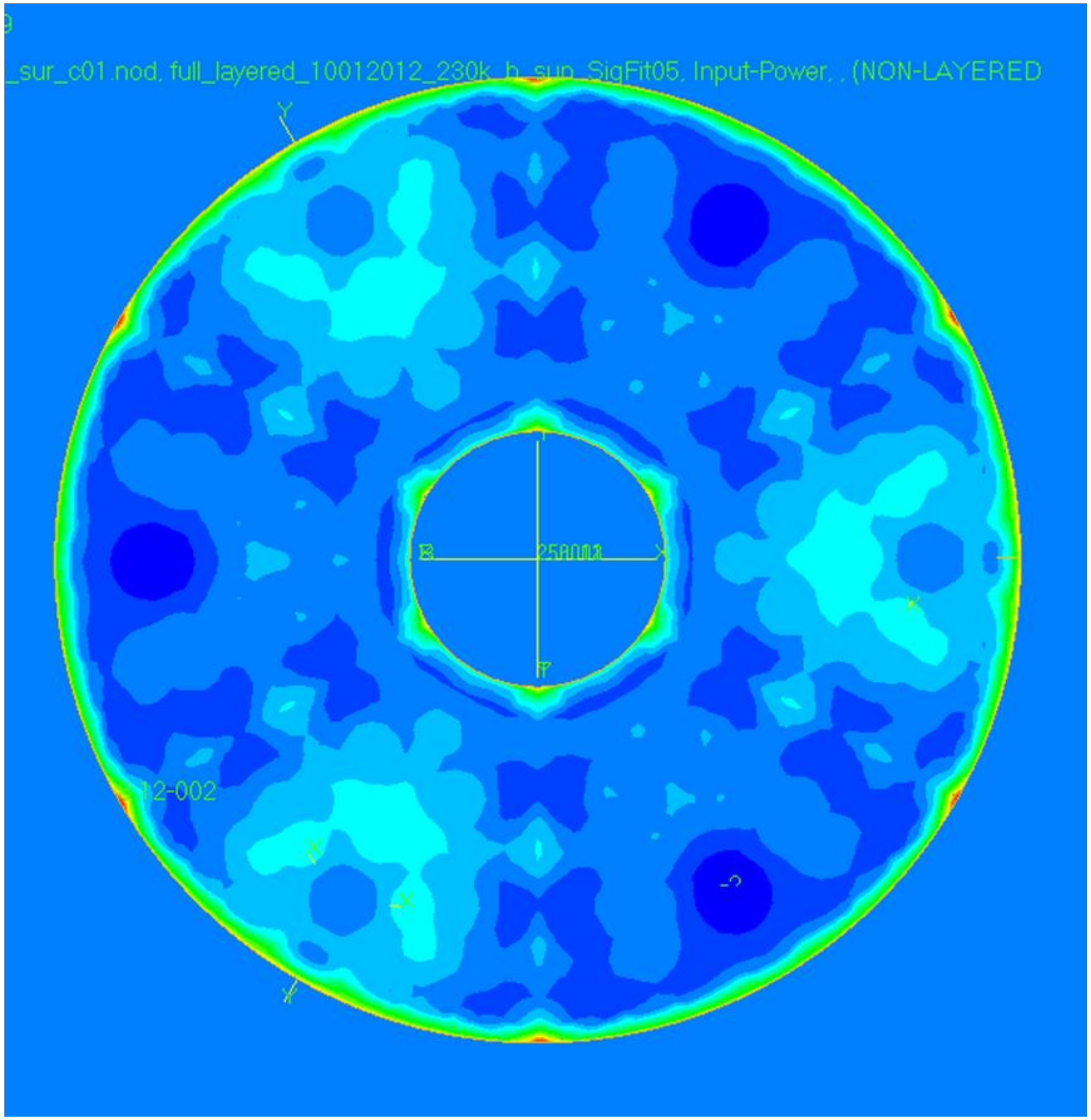
		Residual Surface Error (nm)	
Load Case *	Power (nm)	rms	P-V
-43K Isothermal	207	7	65
1K Axial Gradient and -43K Isothermal	-229	7	52
1K Diametrical Gradient and -43K Isothermal	-78	6	56
1K Radial Gradient and -43K Isothermal	-52	7	51

* 230K CTE Value used for conservatism

Note: Surface figure error from rigid body motion due to gradients across the telescope composite structures are negligible

Primary Mirror performance is very stable over temperature range of interest

PM Surface Figure – Best Fit Plane minus Power due to -43K (293-250K) Temperature Delta



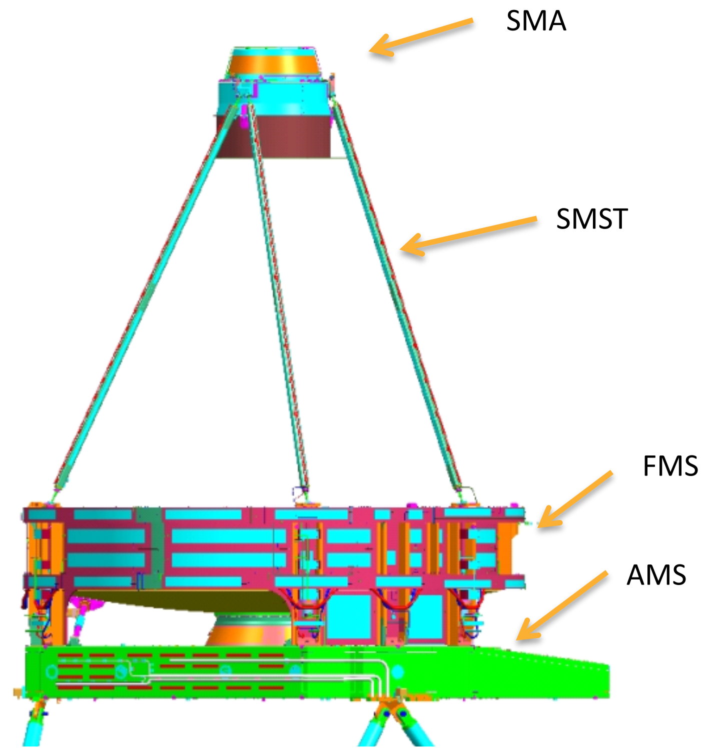
<u>Surface Error</u>

65nm P-V

7nm RMS

Telescope Thermal Configuration

- **Cold biased design - Outer Barrel Assembly (OBA) serves as a passively cooled radiative enclosure to attenuate environment changes.**
- **Heaters control telescope: Aft Metering Structure (AMS), Forward Metering Structure (FMS), Secondary Mirror Assembly (SMA), Secondary Mirror Support Tubes (SMST)**
  - **Minimize radial and diametrical gradients near PMA**
  - **Independent prime, redundant, and survival heaters**
  - **Control telemetry for each heater zone**
  - **Prime & redundant for computer-based control**
  - **Autonomous hybrid heater controllers (HHC) for survival**
  - **OBA heater control located on door mechanism only**
- **MLI on FMS, SMA, OBA OD, SMST surfaces away from PM**



Heater Zones by Region (Prime Side Only)

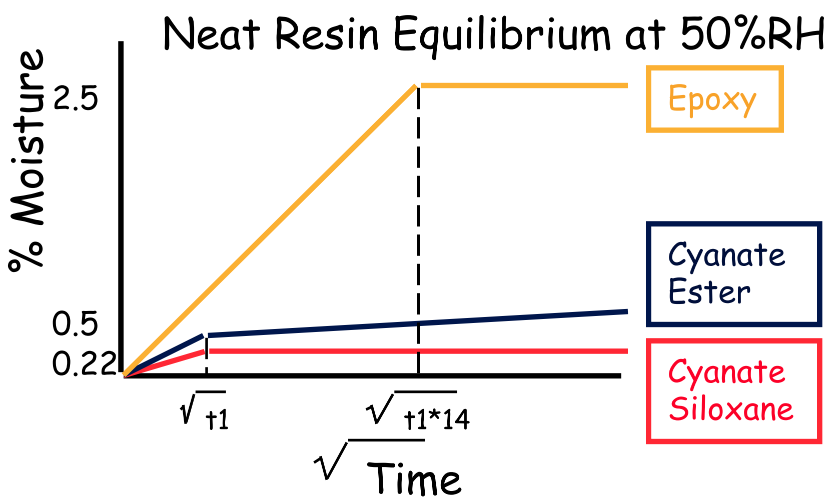
Heater Location	# of Zones	Capacity (Watts)
AMS	24	102
FMS	21	100
SMST	12	106
SMA	5	25

ITT Exelis State of the Art Material Technology Utilized to Provide Stable Telescope

Hybrid Laminates with low CTE, low CME, and high modulus *(patented)*

- 0 CTE (0.0 ± 0.1 μin/in°F) in all inplane directions

Cyanate Siloxane Resin with low moisture uptake *(ITT/Hexcel development)*



Hygro strain
< 15 μin/in

Invar Fittings where required for stability

- CTE: < 0.4 μin/in°F
- Temporal Stability (Invar growth): < 2 ± 1 μin/in/yr

Thermal Operating Considerations

- Telescope system was designed to operate around 293K (Room Temperature)
  - Does not require requalification for warm launch
- Various material considerations influence using the system at colder temperatures
  - Mirror Materials
    - Corning ULE™ is optimized for room temperature applications
    - ULE™ has been tested at 20K with degraded CTE characteristics
  - Structures
    - Laminate optimized for room temperature application
    - CTE characteristics degrade slowly so some level of off-nominal conditions would be acceptable
    - Coupon testing required to validate performance at 250K
  - Bonding Materials
    - GE RTV-566 used to attach mirrors to mounts; qualification required for off-nominal temperatures
  - Mechanisms
    - Precision mechanism pre-load and lubrication optimized for room temperature; pre-load adjustment and alternate lubrication may be required

Re-Use Considerations

- Telescope system designed for room temperature operation
  - Off optimal thermal configuration possible with some level of analysis and retest
  - Consideration of material response, electronic performance, and optical performance required for operating temperatures around 250K
- Some minor rework on the telescope is very low risk
  - Telescopes were designed to be taken apart and refurbished
  - Facilities and support equipment available to test, figure, and recoat PM & SM
- Instrument section is the most doubtful of the configuration
  - Aluminum and heavy
  - Designed for a specific instrument accommodation
  - Not a cost driver to replace with a better form factor
- Outer Barrel Assembly is likely shorter than desired for NASA mission
  - Extension and repositioning is low cost and low risk
- Point of Contact

Dr. Jennifer Dooley – JPL Jennifer.A.Dooley@jpl.nasa.gov

Reuse Preliminary Assessments:

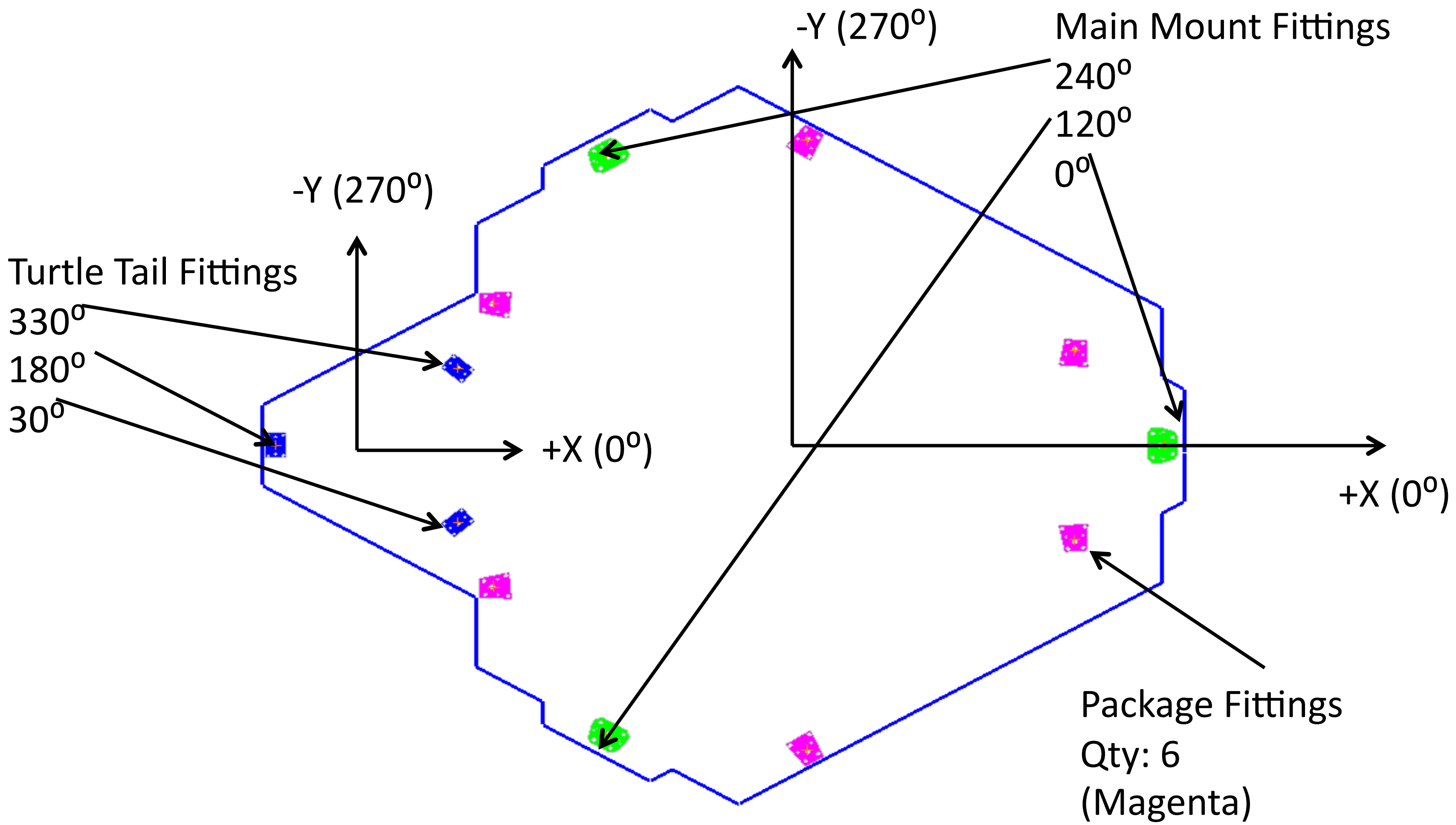
Complete:

- On-going stewardship of the hardware and documentation
- PM Surface figure error predictions at 250K (presented)
- Mechanical ICD for Aft Metering Structure

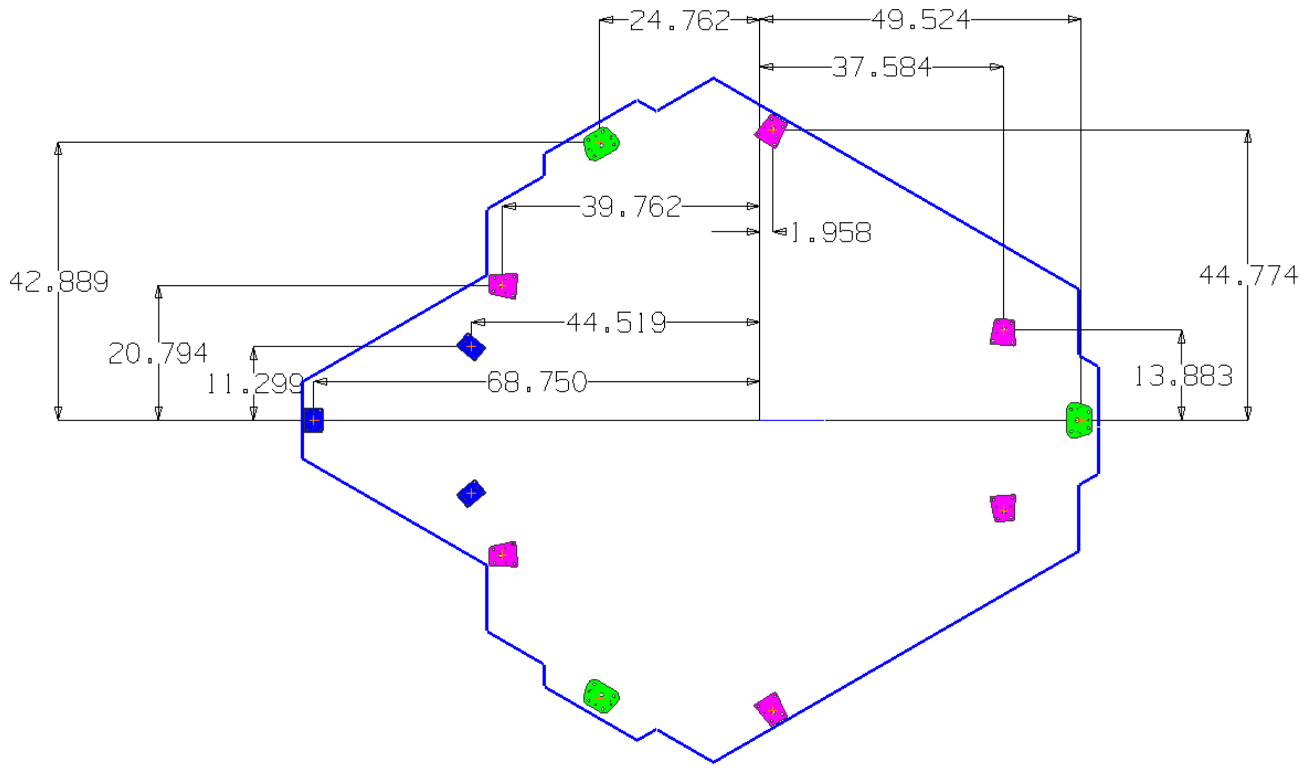
Ongoing and Planned Work:

- Retrieve and organize specifications, budgets, models, drawings, test results, and tech notes
- Baffles - analysis and design considerations
- Actuators – analyze design to enable performance at lower operational temperatures
- Electronics – review board level function applicability
- Structures – coupon level testing to verify performance at lower temperatures
- PM, SM Mirror performance – update performance results for colder operating temperatures with current modeling tools

AMS Fitting Identification



Mechanical ICD



	Location (inches)	
	X	Y
Main Mount Fitting 1	49.524	0.000
Main Mount Fitting 2	-24.762	-42.889
Main Mount Fitting 3	-24.762	42.889
Turtle Tail Fitting 1	-44.519	-11.299
Turtle Tail Fitting 2	-68.750	0.000
Turtle Tail Fitting 3	-44.519	11.299
Package Fitting 1	37.584	-13.883
Package Fitting 2	1.958	-44.774
Package Fitting 3	-39.762	-20.794
Package Fitting 4	37.584	13.883
Package Fitting 5	1.958	44.774
Package Fitting 6	-39.762	20.794

Approximate hang weight capability (launch, instrument(s) configuration dependent):

Package Fittings 1-6: 2,000 lbf

Turtle Tail Fittings 1-3: 500 lbf